DOCUMENT RESUME

ED 280 720 SE 047 883

AUTHOR Pankratius, William J.; Keith, Thomas Mark
TITLE Building an Organized Knowledge Base: Concept Mapping in Secondary School Science.
PUB DATE 28 Mar 87
NOTE 14p.; Paper presented at the Annual Meeting of the National Science Teachers Association (35th, Washington, DC, March 26-29, 1987).
PUB TYPE Reports - Descriptive (141) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Cognitive Processes; Concept Formation; *Concept Teaching; *Learning Strategies; Misconceptions; Models; Process Education; Science Education; *Science Instruction; Secondary Education; *Secondary School Science; Teaching Methods
IDENTIFIERS *Concept Mapping; *Concept Maps; Science Education Research

ABSTRACT

Perspectives on concept mapping and its benefits to students in the learning of scientific concepts are presented in this paper. A concept map is defined as a two-dimensional heirarchical representation of concepts which indicates the relationship between the selected concepts. Aspects of concept mapping addressed in this review include: (1) its structure (consisting of a sample map); (2) construction of a map (specifying the steps involved in mapping); (3) applications (indicating uses in curriculum development, instruction, and evaluation); (4) classroom use (suggesting ways for introducing concept mapping to students); (5) research studies (reviewing one study's findings); and (6) a conclusion (re-emphasizing the instructional value of concept mapping). (ML)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

FD280720

SE047883

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

William J. Pankratius

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☒ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

BUILDING AN ORGANIZED KNOWLEDGE BASE: CONCEPT MAPPING IN SECONDARY SCHOOL SCIENCE

BY

WILLIAM J. PANKRATIUS

WALTON HIGH SCHOOL

MARIETTA, GEORGIA

AND

THOMAS MARK KEITH

MORGAN COUNTY HIGH SCHOOL

MADISON, GEORGIA

presented at

National Science Teachers Association

Annual Meeting

March 28, 1987

BEST COPY AVAILABLE

Introduction

Do you have students who consider each lesson, unit, or course an isolated event? Do you have students who can plug numbers into equations; but get lost when they encounter a word problem? Do you have students who can't handle the math and get turned off in class? Do you have students whose understanding is not that which you assumed was being developed? If so, concept mapping may be the solution.

Student problem solving in secondary school science suffers from the lack of an effective, efficient, extensive, and accessible knowledge base. Students tend to classify problems by the physical and literal features of the problem. "It's a pulley problem". "That's an inclined plane problem". Expert problem solvers abstract scientific principles in order to approach and classify problems. "That's a conservation of momentum situation". "It's a Newton's second law problem".

Students come to our classrooms with a conceptual structure that makes sense in their universe; yet often conflicts with the scientific picture. Their knowledge bases are often riddled with naive misconceptions that are based on their personal experiences. Did you ever hear that light from a candle goes further at night? Or that a worm is not an animal? Or that gravity requires the presence of air? These misconceptions are highly resistant to change.

Concept mapping offers an opportunity to clarify those misconceptions and to give a coherent structure to our students' knowledge bases. Concept mapping opens the door to meaningful learning in the Ausubellian sense--the student must make a conscious effort to recognize and integrate scientific concepts into their cognitive structure.

Concept Maps

Novak, the pacesetter in concept mapping, in Learning How to Learn, defines a concept "as a regularity in events or objects designated by some label". We think with concepts. Concepts are not learned in isolation--we place them in our conceptual network. Concept maps serve to externalize these concepts and improve our conceptual scheme. A concept map is a two dimensional hierarchical organization of the structure of a discipline, a unit of study, or even a paragraph. It indicates the relationships between concepts. It is a dynamic device that changes as our view of the universe is modified and refined.

See Appendix A for a concept map of this presentation.

Structure

Think of a pyramid or a triangle. The most general and inclusive concepts appear at the top of the map. More specific concepts are subsumed under these and appear with examples near the bottom of the map. Each level of the hierarchy contains concepts of the same order of generality. The degree of differentiation among concepts is indicated by the branching of the concept map. Lines connecting the concepts indicate

relationships that link them. Cross links are relationships between concepts on different branches and show the degree of integration of concepts.

The structure of the concept map in Figure 1 has sixteen concepts, four levels of hierarchy, three main branches, and two cross links.

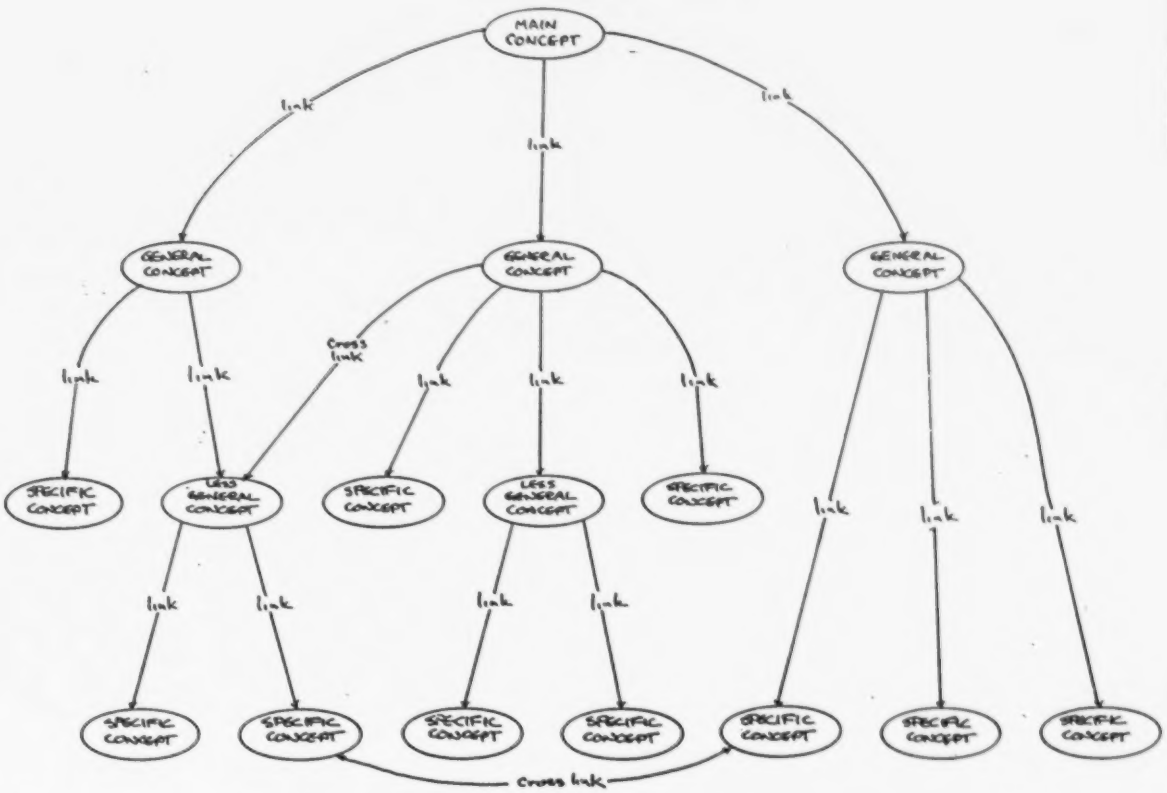


Figure 1. The hierarchical structure of a concept map.

Construction

1. Select a topic. Try a unit in your discipline. Start with a paragraph or even your lecture notes.
2. Pick out the main concept. Choose other key concepts.
3. Rank the concepts from the most inclusive to the most specific. Group the concepts according to level of abstraction and relatedness. More specific concepts can be added here.
4. Arrange the concepts in a two dimensional array. Index cards can be helpful here.
5. Link related concepts and label each link. Look for cross links.

Revise. Revise. Revise. A concept map is never final.

A good unit concept map can be accomplished on an 8 1/2 by 11 sheet of paper turned sideways. Four levels of hierarcy and about 15 concepts appear to be comfortable.

Applications

Concept maps can be used to develop curriculum, as instructional devices, or as evaluation tools.

A concept map of a discipline is a large overview of general concepts and can lead to course concept maps. It's a "better" outline.

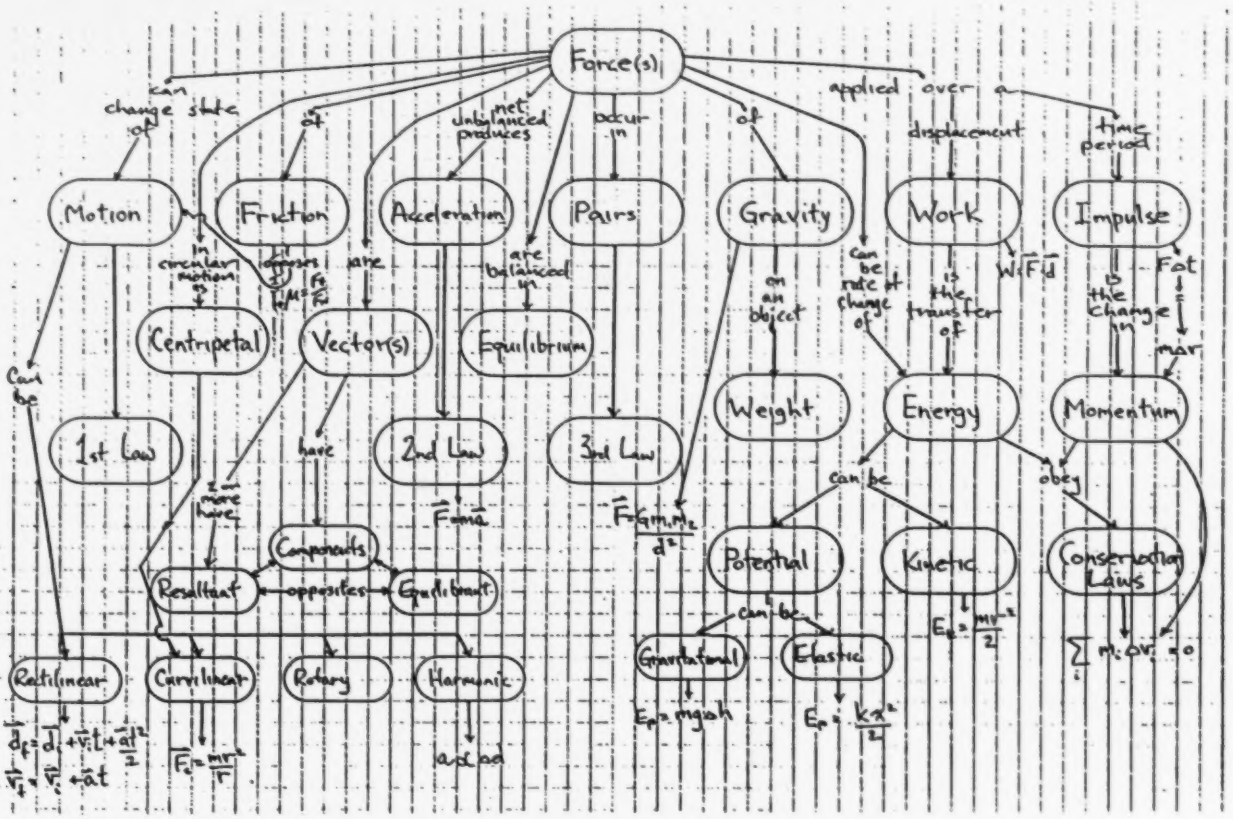


Figure 2. Concept map of the first semester of secondary school physics with force as the central concept.

Plan a tour of the concept map for the subject or discipline. The tour would indicate the general flow of instruction. The natural flow includes top down and bottom up teaching and learning. Each concept could be on the level of a unit of instruction. It makes a "better" lesson plan.

To get to the unit concept map, take the concept map for the course and zoom in on a general concept. Less general concepts are added, and a unit concept map is prepared.

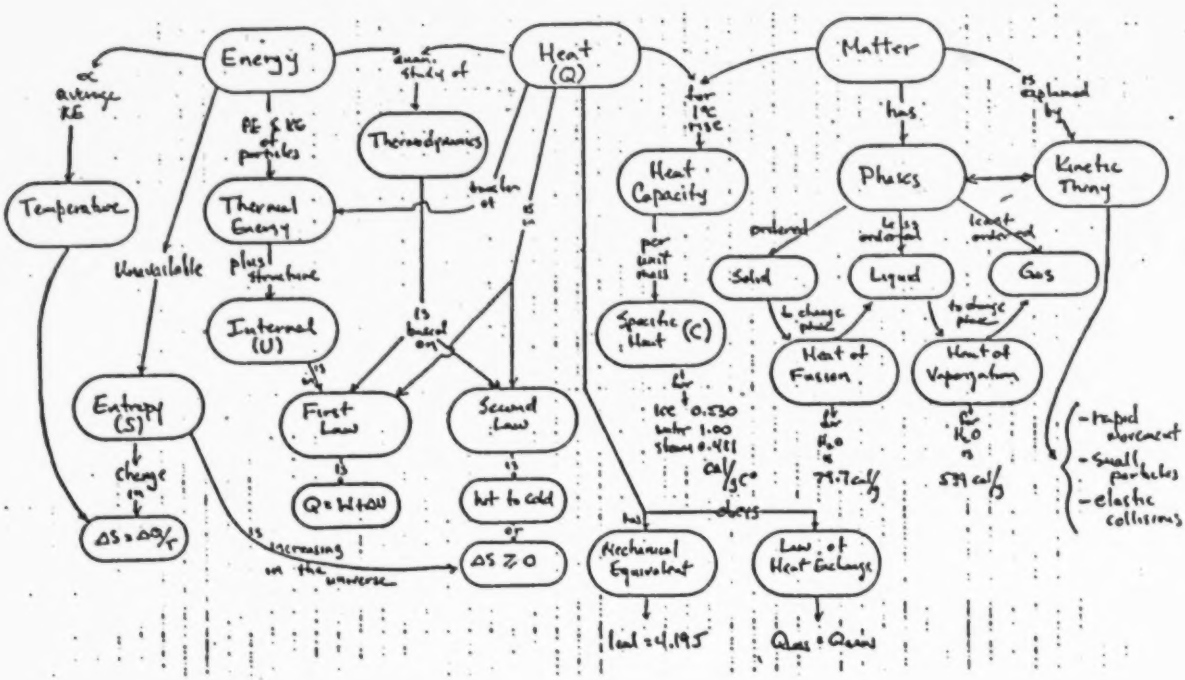


Figure 3. Concept map of the first unit of the second semester of the secondary school physics course depicted in Figure 2. Note the "hook" to energy in Figure 2.

Zoom in on one of the unit's concepts. More specific concepts are discovered and perhaps a concept map of a lecture can be found.

Have your students construct a pre-instructional concept map to find out what they already know.

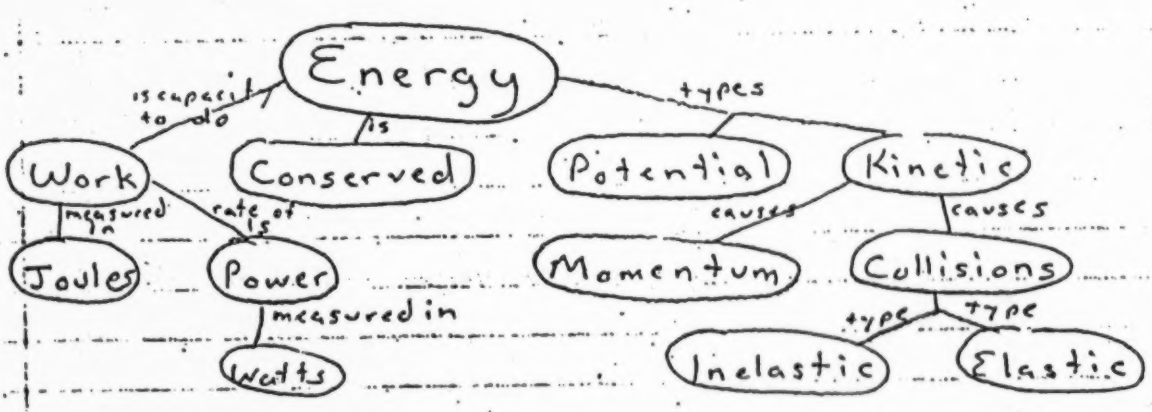


Figure 4. A Student's pre-instructional concept map of a unit on energy. The unit covered the two branches at the right in Figure 2.

Have your students prepare and revise concept maps as the instructional process unfolds. Have them prepare concept maps as unit or course reviews.

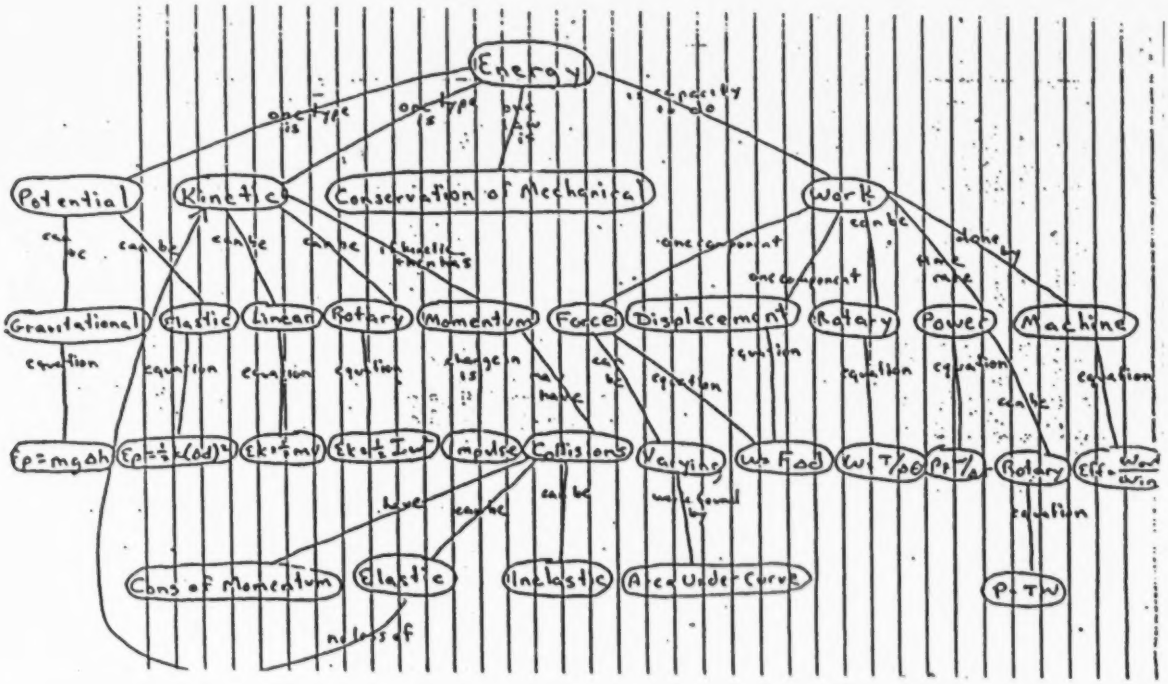


Figure 5. The same student's post-instructional concept map.

Have students prepare concept maps for class discussion, laboratory reports, or text study.

Distribute concept maps to students as course outlines, advance organizers, or lecture notes.

Use concept maps to evaluate instruction. Include test questions designed to uncover relationships between concepts. Include map exercises on your tests.

Remember, there is no one correct concept map. We all think differently.

Starting in the Classroom

An effective way to introduce concept mapping to your students is through a free association word game. Choose a common concept like "table". Some popular responses would include those in Table 1.

chair	kitchen	work
food	dining	dinner
lunch	wood	mahogany
pine	glass	legs
pedestal	data	list
coffee		

Table 1. Student responses to the concept "table".

With the students' help, rearrange the concepts according to related groupings. Let the students add or revise their responses.

chair	location	uses
	kitchen	work
legs	dining room	eating
pedestal	study	lunch
	living room	dinner
made of		coffee
wood		data
mahogany		lists
pine		
glass		

Table 2. Rearrangement of student responses to the concept "table".

Finally draw the concept map and add the connecting words.

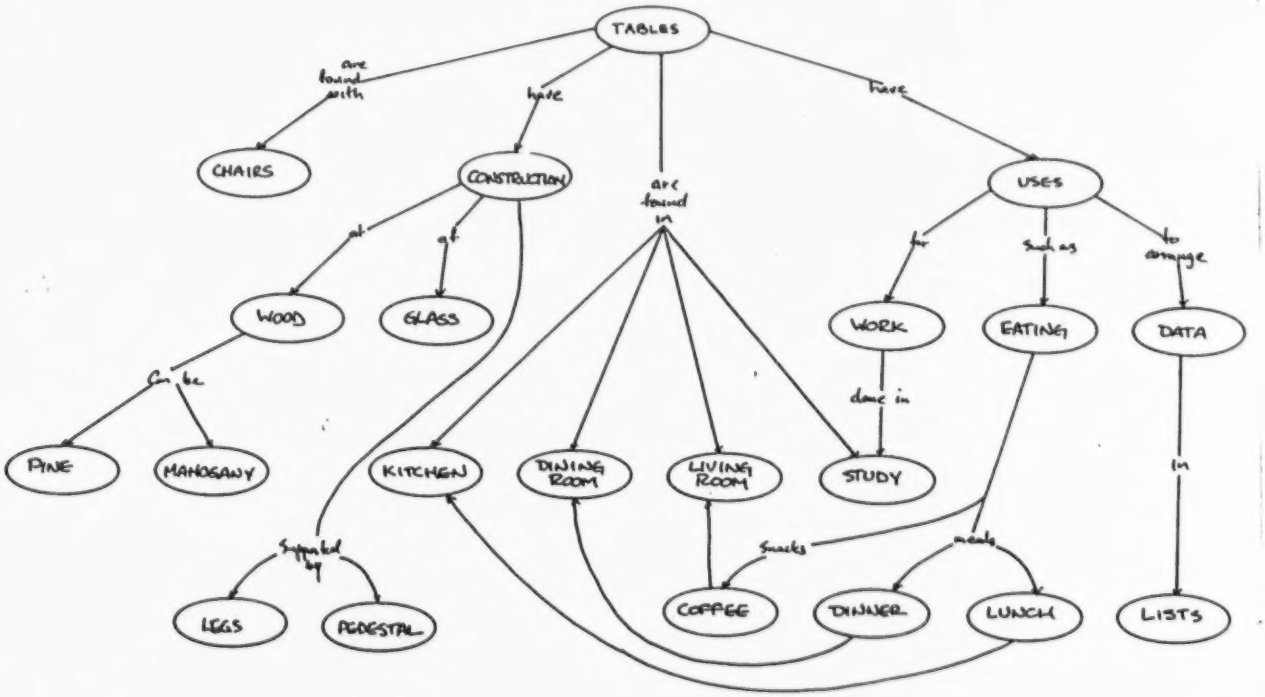


Figure 7. Concept map of the concept "table".

A Unique Approach

Don't be intimidated by the rigid format that has been presented. Take the rules for concept mapping to be your goals as you develop your program. Less formally structured conceptual flow charts or diagrams may also be used effectively in the classroom. Linking words may be absent, formal names of theories and laws may be used, and the map may be primarily teacher prepared. The map may take the form of a dominating wall mounted conceptual display.

A wall mounted concept map for a course has many values. It unites one unit to the next, to the next, and so on. The diagram sets the structure of the class for the students. It dramatically illustrates relationships among concepts from unit to unit as well as within a unit. Students may miss material due to a lack of perception of relatedness even though textbooks may be well ordered in a linear fashion. Course concept mapping on the wall provides the relatedness.

A concept flow diagram can aid in linking seemingly disconnected new material with established concepts. At times in a course, new material must be presented which deviates from the previously established flow of the course. For example, in many texts the gas laws represent a radical departure from stoichiometric relationships. Avogadro's Law and molar-volumes may be effectively linked with prior material with a concept map. The map should highlight links when they occur.

The wall chart promotes class discussions of conceptual links. Course topics can be chronologically dominating for the learner. Concept flow diagramming helps to dispell this disposition. The map dramatizes the necessity to approach chemistry as an ongoing learning experience.

A continuing presence of course organization is also valuable to the daily presentation of material. In the lecture, the map allows for visual referencing of prior concepts upon which the new material will build. The map organizes the progression through the concepts. After the lecture, or after a unit, the map provides a framework for effective recapitulation.

Finally, an entire year of concepts and topics present in the classroom in a single format allows for constructive evaluation of course content. Specific sections of the map may be evaluated as to necessity and placement in the course. Is this concept appropriately addressed at this time? The teacher may consider unit organization and the relationship among units. Would this material fit into the conceptual scheme better at some other point? Course structure can be evaluated efficiently with such a map.

Some Results

Ninth grade physical science

A eighteen week study of 103 ninth grade physical science students yielded positive but not significant results. The students were given instruction in constructing concept maps and chapter outlines. They were required to complete both for seven of the ten units in the course. The first two units were trial

runs. For the tenth, and last unit, of the semester (on motion), the students were given a choice of completing a concept map or a chapter outline. A posttest, consisting of 25 multiple choice questions and 10 short problems, was then administered. The posttest was evenly divided between lower order (knowledge and comprehension) items and higher order (application and analysis) items.

Overall Test Score Means

Group	Original	Adjusted	Covariant MAT Sci
Concept Map	39.8	38.4	43.4
Chapter Outline	36.2	36.7	40.3
No Organizer	32.7	33.4	40.0

Higher Order Test Score Means

Group	n	Original	Adjusted	Covariant MAT Basic
Concept Map	22	17.5	17.2	137.3
Chapter Outline	42	15.4	15.6	134.4
No Organizer	13	13.9	13.8	136.1

Table 3. Adjusted and covariant mean scores.

The adjusted higher order test score means for the concept map group were 10% higher than the chapter outline group and 25% higher than the no organizer group.

Twelfth grade physics

A nine week study of 139 twelfth grade physics students yielded positive and significant results.

Overall Test Score Means

Group	n	Original	Adjusted	Covariant SAT Math
Pre/Post Concept Map	29	16.4	16.0	64.0
Post Concept Map	21	14.8	15.0	61.2
No Concept Map	29	13.4	13.6	61.6

Table 4. Adjusted and covariant mean scores.

Of six classes of physics students, four were given instruction in constructing concept maps. The four experimental classes were required to submit concept maps for two units prior to the unit involved in the study (energy, momentum, work, and power). For the unit under study, two classes were required to submit a concept map prior to instruction (Pre/Post Concept Map group). They were encouraged to change their concept maps as

the unit proceeded, and required to submit a concept map at the end of the unit. The other two experimental classes were required to submit a concept map at the end of the unit (Post Concept Map group). At the end of the unit, a post test composed of thirty multiple choice questions selected from the Ontario Assessment Instrument Pool (Physics) was administered. The test items were primarily higher order questions (application, analysis, and synthesis).

An analysis of covariance for the overall effect (The Omnibus F Test) yielded an F of 4.08 which was significant at $P < 0.05$. A comparison of the weighted means revealed that the means for both treatment groups were significant at $P < 0.05$.

Further analysis of the scores indicated that students whose SAT Math scores were in the middle range (59-67) benefited the most from concept mapping. This Pre/Post Concept Map group's scores were 25.6% higher than the No Concept Map group.

	SAT Math Scores		
Group	High (68-80)	Mid (59-67)	Low (41-58)
Pre/Post Concept Map	17.6	16.7	14.7
Post Concept Map	15.8	14.5	12.8
No Concept Map	15.3	13.3	12.4

Table 5. Posttest mean scores versus SAT Math ranges.

It is of more than passing interest that items involving higher order linking between concepts in the unit were more often answered correctly by the treatment groups. Posttest item six asked, "In order to compare the kinetic energies of two objects moving horizontally it is sufficient to compare only...". The correct response was "the work necessary to stop them". There were 23 correct responses, 19 by the experimental groups. A correct conceptual link between work and (kinetic) energy helped here.

Conclusion

The student is not just a passive consumer of information. If meaningful learning is to take place it must be caused by the learner. Concept mapping succeeds in getting students more involved in learning how to learn. It gives them an active opportunity to integrate and synthesize new knowledge. If the concept map is an integral part of the course, the students become keyed into and involved in discovering new relationships among concepts.

The teacher is not just a passive supplier of information. If meaningful learning is to take place it must be inspired by the teacher. Concept mapping succeeds in getting teachers more involved in how students learn. The teacher becomes the stimulus and plans courses along links between concepts. Then, science, and science teaching, and science learning become a flow of conceptual change.

BIBLIOGRAPHY ON CONCEPT MAPPING

Ault, R. A. Jr. (1985). Concept mapping as a study strategy in earth science. Journal of College Science Teaching, 15(1), 38-44.

Ausubel, D. P., Novak, J. D., & Hanesian, H. (1978). Educational psychology: A cognitive view. (2nd ed.). (1986 Reprint). New York: Werbel & Peck.

Cliburn, J. W., Jr. (1986). Using concept maps to sequence instructional materials. Journal of College Science Teaching, 14(5), 38-44.

Gorodetsky, M. & Hoz, R. (1985). Changes in the group cognitive structure of some chemical equilibrium concepts following a university course in general chemistry. Science Education, 69(2), 185-199.

Heinze-Fry, J. A., Crovello, T. J., & Novak, J. D. (1984). Integration of Ausubelian learning theory and educational computing. The American Biology Teacher, 46(3), 152-156.

Lehman, J. D., Carter, C., & Kahle, J. B. (1985). Concept mapping, vee mapping, and achievement: Results of a field study with black high school students. Journal of Research in Science Teaching, 22(7), 663-673.

Malone, J. & Dekkers, J. (1984). The Concept Map as an Aid to Instruction in Science and Mathematics. School Science and Mathematics, 84, 220-231.

Moreira, M. A. (1979). Concept maps as tools for teaching. Journal of College Science Teaching, 8(5), 283-286.

Novak, J. D. (1976). Understanding the learning process and effectiveness of teaching methods in the classroom, laboratory, and field. Science Education, 60(4), 493-512.

Novak, J. D. (1977). A theory of education. Ithaca, N. Y.: Cornell University Press.

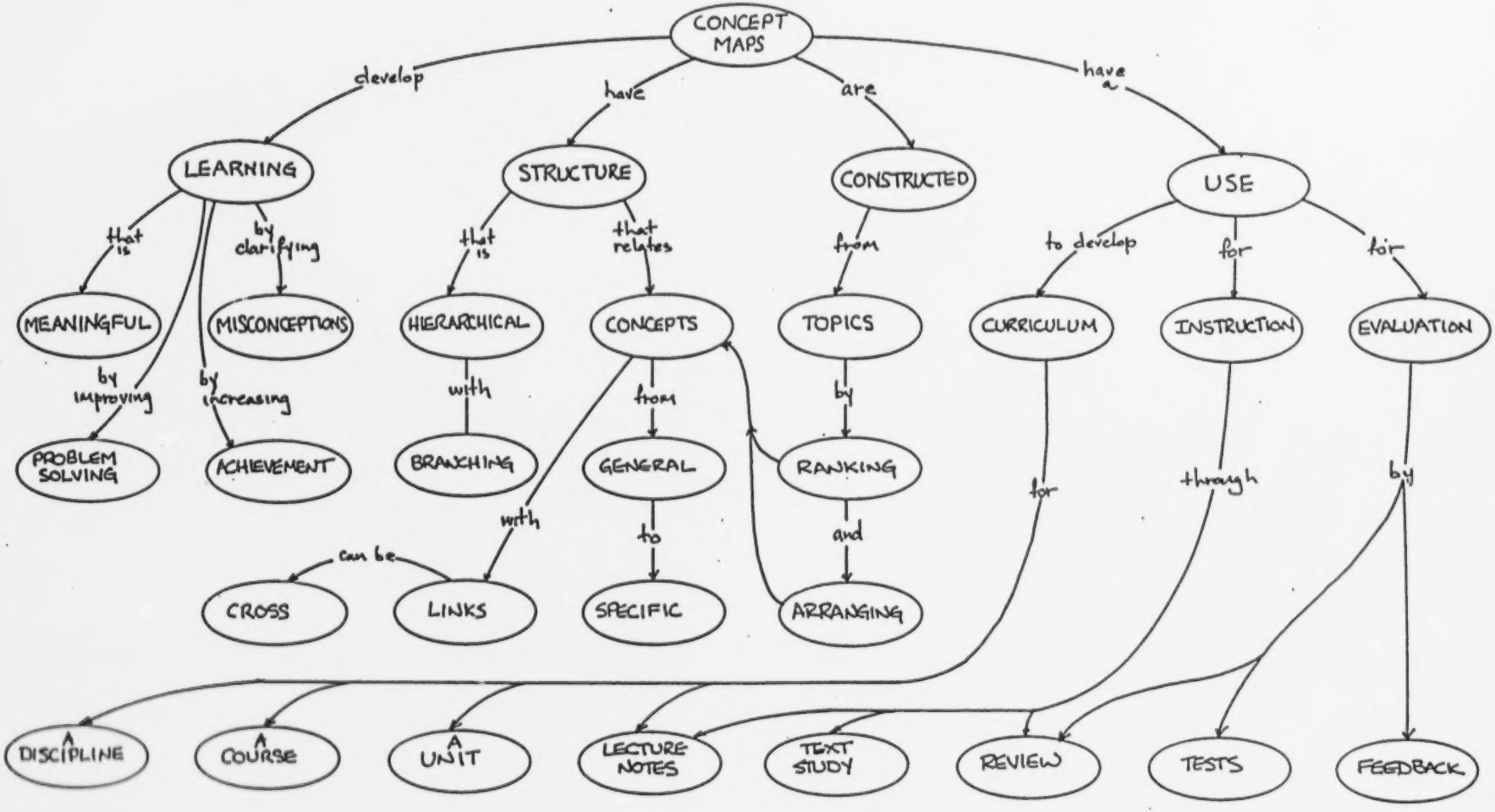
Novak, J. D. (1981). Applying learning psychology and philosophy of science to biology teaching. The American Biology Teacher, 43(1), 12-20.

Novak, J. D. (1984). Application of advances in learning theory and philosophy of science to the improvement of chemistry teaching. Journal of Chemical Education, 61(7), 607-613.

Novak, J. D. & Gowin, D. B. (1984). Learning How to Learn. New York, NY: Cambridge University Press.

Novak, J. D., Gowin, D.B., & Johansen. (1983). The Use of Concept Mapping and Knowledge Vee Mapping with Junior High School Students. Science Education, 67, 625-645

Stewart, J., Van Kirk, J., & Rowell, R. (1979). Concept Maps: A tool for use in biology teaching. The American Biology Teacher, 41(3), 171-175.



A Concept Map of Concept Maps

Appendix